ESIG-2000 APPLICATIONS INFORMATION

SETTING THE STANDARD FOR LOW COST IMAGE GENERATION

The ESIG®-2000 sets the standard for low cost image generators with capabilities previously available only in high-end systems. Rather than rely on inherently limited workstation technology, the ESIG-2000 incorporates the technology and architecture of our high performance ESIG-3000 into a compact and cost effective package. The result is an image generator with the versatility, sophisticated scene management, and image quality that characterize today's finest visual systems–at a fraction of the cost.

ESIG-2000 FEATURES

The power behind the ESIG-2000 is state-of-the-art VLSI and custom ASIC technology designed specifically for the visual system market. Features of the ESIG-2000 include:

- **Configurable Design.** The system allows tailoring of update and refresh rates, surface and texture capacity, video output resolution and format, and supporting peripherals. Modular design allows easy expansion for future growth.
- **Multiple Viewports.** Multiple high resolution displays from a single system, each with separate host controlled viewing direction and field of view.
- **Choice of Low-Cost Displays.** Fully programmable video buffers enable the use of cost effective commercial displays or specialized displays requiring non-linear image mapping.
- **Advanced Texture.** Crisp, stable texture for essential detail and realism on any surface in the scene regardless of altitude or viewing distance. Full color, contour and photographic texture, give realism unique in the low cost market.
- **Realistic Sensor Simulation.** Built-in circuitry for economical, high fidelity NVG and IR.
- **Compact Packaging.** 25-inch high floor cabinet or EIA standard 19-inch rack mount.

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ESIG-2000 - TYPICAL APPLICATIONS:

NETWORKED SIMULATORS - Large scale networking of simulators demands a high cost-performance ratio from modern image generation systems. High visual performance is needed to achieve the scene detail and realism required by the training task across multiple channels. The large number of trainers in the network, however, demands a low unit cost. ESIG-2000 is tailor-made for this challenge. By capturing the essential algorithms of high-end image generators into cost effective, VLSI and custom ASIC circuitry, the ESIG-2000 delivers the flexibility, power, advanced scene management, and image quality required to provide necessary realism and multi-channel performance for effective networked training.

LOW COST FLIGHT SIMULATION - Taking advantage of Evans & Sutherland's extensive experience in producing image generation systems for flight simulators, ESIG-2000 incorporates features essential to basic flight simulation. These include: advanced texture for speed and height cues at all operating altitudes, realistic weather and atmospheric effects, accurate depiction of lighting and visual landing aids, and sophisticated scene management to provide necessary scene detail throughout the database–not just around airport and target areas. Programmable video output enables the use of cost effective, commercial displays. Compatibility with the ESIG® family of image generators allows for the cost effective development and use of visual databases.

PART TASK TRAINERS - The power and versatility of the ESIG-2000 makes it applicable for a wide variety of part task training applications which have previously employed under-powered workstations or costly, high-end image generators. High fidelity conduct-of-fire training is now economically practical with the high update rate, resolution, scene fidelity, scene management, and image quality of the ESIG-2000. Its built-in sensor simulation capability enables realistic depiction of NVG and infared imagery. The compact size of the ESIG-2000, featuring only 9 card types, makes it ideal for strap-on and embedded training, and for part-task engineering simulation where realistic, high update rate imagery is essential but budget constraints preclude a high-end image generation system.

MARITIME SIMULATION - Typically operating at low update rates with wide fields of view and constrained by very tight budgets, ship bridge pilotage simulation has historically been relegated to extremely low performance image generation systems. By trading update rate for channel capacity, the low cost ESIG-2000 meets this challenge by providing the required field of view at a cost comparable to the much less capable systems currently in use. Periscope simulation, on the other hand, requires a single channel at a fast update rate to maintain scene integrity during rapid scan and high magnification. The ESIG-2000 delivers this range of performance with the scene management, image quality, and special effects that are vital to realistic maritime simulation.

DRIVING SIMULATION - Realistic visual scene performance has previously been unavailable to the driving simulation user with a limited budget. Up to now, fast update rates and high scene detail have been limited to the domain of the high performance image generator. ESIG-2000 provides the solution to this dilemma, by delivering the speed and scene detail of today's high-end image generators, in a cost effective package. Additionally, the ESIG-2000 can be tailored to meet the training requirements for tank and truck drivers, and high speed emergency vehicle operators.

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ESIG-3000 SYSTEM INFORMATION

HIGH PERFORMANCE IMAGE GENERATORS

High performance image generators are used where high scene density and realism, and complex threat models are required. Applications include low-level and nap-of-earth flight, combat mission rehearsal, weapons tactics, situational awareness, full mission simulation and space operational training. These systems also support requirements for research and engineering development.

ESIG 3000 FEATURES

The ESIG-3000 is a versatile, general purpose system that offers customers the best price/performance ratio in the industry. It incorporates the best features found in the Evans & Sutherland broad line of image generators and combines them with advanced developments that include:

- **Powerful Range Buffering**. ESIG-3000 uses an R-buffer and hybrid R-buffer approach to occultation to improve moving model management. Up to 253 moving objects can be addressed while the system maintains proper occultation throughout.
- **High Modularity and Flexibility**. The system's advanced electronics and VME architecture helps support multiple interfaces and future expandability.
- **Database Compatability.** The ESIG-3000 exhibits a high degree of database compatability with ESIG-200 through ESIG-1000 systems, protecting customers' past investments for progress into the future.
- **High-Fidelity Sensor Simulation**. Multiple on-line color tables allow channels to be switched from visual to sensor simulation instantaneously. Provides wide dynamic range needed for infrared, low light level TV and light intensification devices.
- **Non-Linear Image Mapping**. Allows accurate correction for non-linearities without popping, cracking or scene overload.
- **Photo-Realistic Texture**. Provides continuous emergence of texture detail over extremely wide viewing ranges. Types available range from new full-color to contour texture to "select texture," which uses one texture map to efficiently mix two other texture and color patterns.
- **Compact Design**. Using VLSI circuitry, the unit houses a typical three-channel processor in a single 19" cabinet. This streamlined configuration means lower acquisition and life cycle costs.

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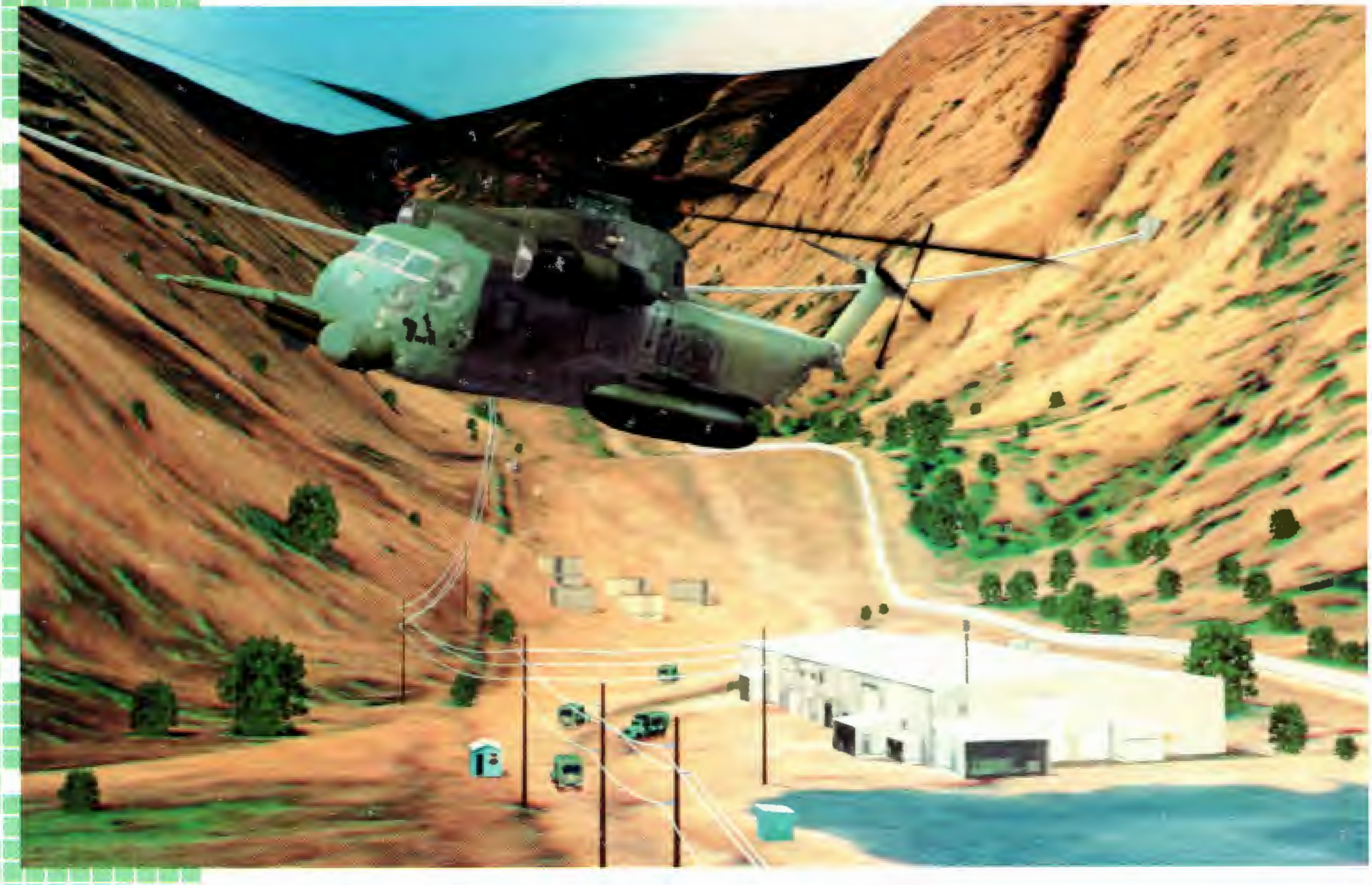
ESIG-3000 PERFORMANCE SUMMARY

MODES	• Day/Dusk/Night/NVG (Night Vision Goggles)/FLIR (Forward Looking Infrared)
CHANNELS	• Up to 8 Channel Processors
VIEWPOINTS	• Multiple viewpoints available, depending on specific application
VISUAL PRIORITY	**• Range Buffer (R-Buffer)** • Fixed-relationship priority also supported **• Proper occultation for all FOV, including 180 degrees**
UPDATE/REFRESH RATE	• 60 Hz or 50 Hz standard
RESOLUTION	**• Expandable to over 1.5M pixels per channel**
DISPLAYED SURFACES (60 HZ)	
• PER CHANNEL	**• Expandable to over 3,000**
• TOTAL FOR SYSTEM	**• Up to 24,000**
DISPLAYED LIGHTS (60 HZ, 0 POLYGONS)	• Calligraphic lights optional
• PER CHANNEL	**• Up to 7,500; trade 2.5:1 with polygons**
• TOTAL FOR SYSTEM	**• Up to 60,000**
DISPLAY FORMAT	• Raster; 2:1 vertical interlace standard • Pixels can be packed into non-rectangular raster shapes for optimizing resolution **• Non-interlace configurations available**
DISPLAY DEVICES	• Software programmable output to drive a variety of display devices: - Calligraphic monitors or projectors - Head- or eye-slaved displays - Direct view CRT monitors, CRT projectors, light valve projectors - Helmet mounted displays - Display devices with non-rectangular active display areas
DISTORTION CORRECTION	**• Non-Linear Image Mapping (NLIM) hardware standard**
COLORS	• Four on-line 512-entry color tables • Additional 1024 material types • Two entries per polygon to serve simultaneous visual and sensor channels
TEXTURE	• Hardware is standard **• Up to 256 high resolution maps (128x128)** **• Programmable map resolution, from 64x64 up to 512x512** • 4 texture maps per polygon **• Full-color texture** • Texture motion for animation/motion without using dynamic coordinate systems (for clouds, water, smoke, etc.) • Contour texture for complex shapes with high edge quality • Modulation texture for "wallpaper" texturing
DATABASE MANAGEMENT	• Multiple LOD on terrain and features • Fade LOD blending
OVERLOAD TECHNIQUES	• Dynamic level of detail range adjustment, field time extension, frame rate update
MOVING OBJECTS	**• Up to 253 addressable moving objects**
ANIMATION	• Up to 256 different representations per animated object, for animation via rapid cycling
SIMULATION FUNCTIONS	
• COLLISION DETECTION	• Reports interference of point(s) on ownship or other Dynamic Coordinate Systems (DCS) with predefined objects in the database
• HEIGHT ABOVE TERRAIN	• Reports height of host-defined points or DCSs above terrain surface or above database features
• LINE-OF-SIGHT RANGING	• Reports range from viewpoint to specific database features in field of view
• INTERVISIBILITY	**• Reports intervisibility between points in database, 360° coverage**
LANDING LIGHTS	• Multiple lobe representations per channel • Steerable lobe searchlight
LIGHT PATTERNS	• Flashing • Rotating • Directional • Strobing
ATMOSPHERIC EFFECTS	• Clouds • Glare • Thunderstorm cell • Fog/haze • Scud • Wet runway • Ground fog • Horizon glow • Snow covered runway • Patchy fog • Lightning
SURFACE EFFECTS	• Flat shading • Self luminous surfaces • Smooth shading • Transparency • Fixed shading
SENSOR SIMULATION	• Electro-Optical Sensor Simulation • Infrared sensor simulation • Enhanced dynamic range of intensity calculations for IR simulation
GENERAL PURPOSE COMPUTER	**• Internal VME 68K-based** **• Ethernet**, HSD and other interfaces available

Bold type indicates significant new features in the ESIG-3000.

Note: Some specifications are dependent on overall system configuration and database design, resulting in tradeoffs to optimize IG performance for a specific application.

ESIG-4000 SYSTEM INFORMATION



HIGH PERFORMANCE IMAGE GENERATORS

High performance image generators are used where high scene density and realism, and complex threat models are required. Applications include low-level and nap-of-earth flight, combat mission rehearsal, weapons tactics, situational awareness, full mission simulation and space operational training. These systems also support requirements for research and engineering development.

ESIG-4000 FEATURES

The ESIG-4000 is a high performance system that brings a revolutionary new approach to computer image generation. The unit uses new system architecture to process terrain and features in both hardware and modeling tools, dramatically reducing database generation turnaround time to as little as 48 hours. This capability is particularly critical for true mission rehearsal performance and a key reason why the ESIG-4000 was selected for the U.S. Air Force SOF ATS program. Other key features of the system include:

- **"On-the-fly" Conforming.** Features are combined with the terrain in the hardware, automatically determining their proper position with each other.
- **Range-Buffer for Generalized Visual Priority**. Provides correct visual occultation for all database features - moving or static, while allowing a greater number of moving models to be included throughout all scenes.
- **Full-Color Terrain Texture**. ESIG-4000 provides full three-color terrain textures to remove color constraints and allow for database realism. A unique "global texture" process facilitates greater level of detail and increased resolution wherever needed within each scene.
- **Robust Non-Linear Image Mapping**. The system uses an advanced correction function that allows projection of distortion-free images on a wide variety of curved projection surfaces.
- **Increased Realism and Database Modeling Efficiency**. The ESIG-4000 permits each instance of a library feature to have the correct size and orientation, thereby increasing database realism and reducing modeling time.
- **Enhanced LOD Management**. Using a new technique called "betweening," the ESIG-4000 allows terrain and features to transition toward lower level of detail in a smooth, continuous manner. Betweening simplifies database modeling and reduces processing time.
- **Large Area Database Capacity**

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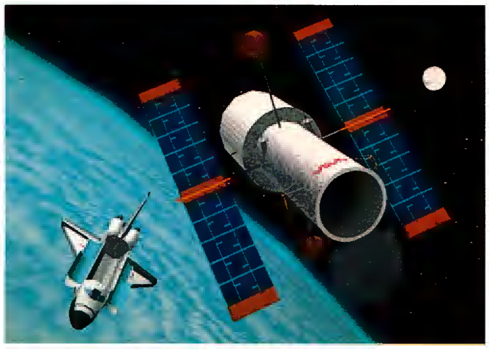
ESIG-4000 FEATURE HIGHLIGHTS

PRIMARY PRODUCT EMPHASIS	• Rapid database generation for mission rehearsal requirements • Efficient database production to reduce costs of frequent database creation • Highest in performance and capacity
VISUAL PRIORITY	• Range Buffer (R-Buffer) - Provides full occultation freedom for both moving and fixed objects - Supports interpenetration • Sub-pixel R-Buffer for high-quality anti-aliased polygon edges • Proper occultation for all fields of view, including 180 degrees
TERRAIN/FEATURE SEPARATION	• Separate terrain and feature databases permits very rapid database generation • Terrain stored as grid of elevation values, providing significant data compression • Terrain and features "conformed" (combined) in the hardware at run time • Flexible conforming modes, including: - Origin conformal for "point" features such as trees and houses - Line conformal for "linear" features such as power lines - Surface conformal for features such as runways, pipelines, forest canopies
RESOLUTION	• 250K to over 1.5M pixels per channel available with modular hardware configurations
DISPLAYED SURFACES (60 HZ)	
• PER CHANNEL	• 1,500 to 10,000 available with alternate resolutions and/or hardware configurations
• TOTAL FOR SYSTEM	• Up to 24,000 per Environment Processor
DISPLAY DEVICES	• Software programmable output to drive a variety of display devices, including - Variable acuity displays - Head - or eye-slaved displays
DISTORTION CORRECTION	• Non-Linear Image Mapping (NLIM) hardware standard - Wide dynamic range to drive advanced displays such as variable acuity - Dynamic NLIM option available - Compatible with all FOVs, including ≥ 180° - No capacity or performance compromise
FEATURE TEXTURE	• Up to 384 high resolution maps (128x128) • Programmable map resolution, from 16x16 up to 512x512 • 4-texture maps per polygon for special effects, contour cutouts, high frequency detail, etc. • MIPmap LOD implementation for superior anti-aliasing • Can also be combined with Global Texture on terrain for up to 9-levels of micro-detail • Full-color capability
GLOBAL TEXTURE	• For texturing terrain topology with photos or synthetic data, separate from Feature Texture • Full-color texture, for complete RGB freedom • Up to 20 MIP levels, for texel size down to fractions of a meter
DATABASE MANAGEMENT	• Separate databases and LOD processing for terrain and features, allows terrain LOD and feature LOD to be optimized independently • "Betweening" for continuous LOD transitions, allows shorter LOD transition ranges, providing more efficient polygon usage and higher scene density • Can classify each feature as one of 16 types, and control LOD of each type separately • Capability to process database multiple times to optimize LOD for different FOVs • Area-of-Interest (AOI) LOD management for LOD optimization across AOI inset/background
FEATURE INSTANCING	• Provides not only position offset, but also scale (size) and orientation (heading) for each instance of a library feature
TRANSPORT DELAY	• 3-field times standard for ownship (i.e. 50 msec at 60 Hz including display field) • Shorter times available for special applications

Note: Some specifications are dependent on overall system configuration and database design, resulting in tradeoffs to optimize IG performance for a specific application.

HIGH PERFORMANCE IMAGE GENERATORS: ESIG-1000



Satellite data from which certain photo texture is derived, here and in the associated brochure, © CNES 1988 SPOT Image Corporation.

High performance image generators are used where high scene density and realism, and complex threat models are required. Applications include low-level and nap-of-earth flight, combat mission rehearsal, weapons tactics, situational awareness training, and full mission simulation. Because these systems are modular, reconfigurable, and expandable, they ideally support simulation requirements in research and engineering development laboratories as well.

The latest high performance image generator is ESIG-1000 which is upward compatible with the CT6 system and provides enhancements which include:

- Higher texture map capacities. ESIG-1000 provides up to 320 texture maps on-line, and over 32,000 texture maps can be dynamically paged. The large number of maps and the ability to blend several maps on a feature allows large areas of photo-specific terrain to be represented over a very large altitude range.
- Larger environment memory. A primary benefit is high feature density in narrow field sensor simulation.
- Higher channel capacity. Channels can display up to 3,000 polygons depending on configuration.
- More moving models for threat environments. Up to sixteen are handled by powerful new generalized occulting hardware, and up to 64 more are movable with some constraints.
- Level of detail management across inset/background for area-of-interest displays.
- Genlock to external sync available.

Evans & Sutherland high performance image generators have been selected by customers which include:

- Boeing Helicopters
- Bell Helicopter Textron
- McDonnell Douglas Helicopter Company
- U.S. Marine Corps AH-1W
- U.S. Army Research Institute Simulator Complexity Test Bed
- U.S. Air Force F-15E
- NASA Johnson Space Center Shuttle Engineering Simulator
- NASA Langley Research Center
- U.S. Navy Landing Craft Air Cushion (LCAC)
- General Dynamics
- Grumman Corporation
- Mitsubishi Heavy Industries
- Fuji Heavy Industries
- Rockwell International
- German Air Force Tornado
- German Air Force F-4F

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ESIG-1000 IMAGE GENERATOR SPECIFICATIONS

Modes	Day/Dusk/Night
Viewpoints	Up to 4
Channels	Up to 8 per viewpoint
Update Rate	50 or 60 hz. (Higher rates are available for specific applications)
Displayed polygons (at 50 hz.)	
Per channel	1,500 (3,000 optional)
Per viewpoint	7,000
Displayed lights (at 50 hz.)	
Per channel	4,000 (8,000 optional)
Per viewpoint	20,000
Resolution	262,000 to 1,048,000 pixels per channel (software configurability available)
Scan Standards	Software programmable/switchable to drive a variety of monitors and projectors
Display format	Raster
Distortion Correction	Nonlinear image mapping and dynamic off-axis correction available to fit a wide range of projection geometries
Colors	Up to 8 on-line software selectable sets of 256 RGB values each, per channel, either full color or monochrome
Texture	128 high resolution texture patterns or 256 standard resolution plus 64 high resolution patterns on-line without capacity reduction
	Photo-derived or analytic texture
	Modulation texture
	Contour texture for realistic representation of irregular edges which are sharp at all ranges
	Up to 4 texture maps per polygon
	Up to 64 texture motion systems for special effects without using dynamic coordinate systems or other system resources
	Dynamic texture map paging available for over 32,000 maps
Data Base Management	Scene management and overload response mechanisms enable systems to routinely operate near specified capacities and concentrate scene detail near the pilot's viewpoint
	Channelized polygon management for load optimization in each channel
	Virtually unlimited levels of detail for terrain and features
Moving Models	Up to 16 with unrestricted movement per viewpoint
	Up to 64 additional moving models per viewpoint with some restrictions
Animation	Up to 128 representations per animated object
Collision Detection	Reports interference of ownship and other moving models with predefined objects in the data base
Height Above Terrain	Reports height and slope of terrain below ownship and below moving models
Laser Rangefinding	Reports range from viewpoint to specific data base features
Threat Occulting	Reports if specified data base features are visible (not occulted)
Surface effects	Flat shading, fixed shading, and smooth shading (including textured surfaces)
	Color blending, transparency, and self-luminous surfaces
Lighting effects	Cultural lighting, airport and runway lights such as VASI and other directional lights, strobes, rotating beacons
	Landing light lobes
	Up to 4 flares
	Steerable searchlight capability
Atmospheric effects	Clouds, fog, haze, scud, precipitation, lightning, and horizon glow. These effects are calculated at the pixel level for correct visibility of three dimensional objects in the scene.

CT6 is a registered trademark of Rediffusion Simulation applicable to systems designed and manufactured by Evans & Sutherland.

Exact specification may depend on system configuration and trade offs to meet user performance requirements. 11/89

LOW COST IMAGE GENERATORS: ESIG-100 ESIG-200 ESIG-500 ESIG-600

These systems adopt the architecture and provide a cost optimized subset of the features found in our high performance ESIG-1000 image generator. Reliability, maintainability, and availability of these systems are proven. For instance, the system level mean time between failure of a representative 5-channel ESIG-500 system exceeds 1,000 hours and mean time to repair is under 30 minutes. Very large scale integration (VLSI) and efficient packaging yield compact systems with low life cycle cost. Four channel ESIG-100 and ESIG-200 systems, for example, occupy a single standard cabinet.

ESIG-100	A newly introduced, low cost system where each channel displays 500 textured surfaces updated at the frame rate.
ESIG-200	(Same as SPX-200) A night/dusk system which updates and refreshes at a rate of 30 hz. Each channel processes 225 textured surfaces and 4,800 calligraphic lights.
ESIG-500	(Same as SPX-500) A day/dusk/night system. In daylight mode each channel displays 500 textured polygons and 1,000 lights. In night/dusk mode 500 polygons and 5,000 lights can be displayed per channel. Calligraphic lights are available.
ESIG-600	A newly introduced day/dusk/night system. Each channel displays 1,000 textured polygons and 1,000 lights in daylight mode. 1,000 polygons and 5,000 lights are displayed in night/dusk mode. In addition to modulation texture, ESIG-600 provides contour texture for realistic representation of irregular edges which are sharp at all ranges. Calligraphic lights and nonlinear image mapping are available.

Since their introduction, more than 160 of these systems have been sold. No other image generator product comes close to this measure of success. These systems have been selected in a substantial majority of civil airline acquisitions, and for major military programs which include:

- U.S. Navy F-14D/A-6F
- U.S. Navy T-45
- U.S. Navy EA-6B
- U.S. Navy Submarine Tactical Visual Training System (STVTS)
- U.S. Air Force F-16
- Swiss Hawk
- British Nimrod
- U.S. Navy S-3B

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LOW COST IMAGE GENERATOR SPECIFICATIONS

In general, these systems provide the following features:

- Multiple viewpoints.
- Multiple channels per viewpoint.
- Photo-derived and analytic texture without capacity reduction.
- Advanced antialiasing.
- Powerful scene management and overload response mechanisms which enable systems to routinely operate near specified capacities and concentrate scene detail near the pilot's viewpoint.
- Multiple moving models to support weapons tactics, in-flight refueling, formation operations, and other requirements.
- Height above terrain and collision detection.
- Calligraphic lights where bright, high resolution lighting cues are essential. One important application is target detection/recognition at acceptable ranges, where calligraphic light-enhanced models are used.
- Lighting effects to simulate cultural lighting, airport and runway lights such as VASI and other directional lights, strobes, rotating beacons, and landing light lobes.
- Atmospheric effects including clouds, fog, haze, scud, precipitation, lightning, and horizon glow. These effects are calculated at the pixel level for correct visibility of three dimensional objects in the scene.
- Animation to simulate afterburner engagement, tracers and gunfire, missile plumes, explosions, dust, rotor wash, and other special effects.

	ESIG-100	ESIG-200	ESIG-500	ESIG-600
Modes	Day/Dusk/Night	Dusk/Night	Day/Dusk/Night	Day/Dusk/Night
Viewpoints	1	1	Multiple	Multiple
Maximum channels per viewpoint	4	8	8	8
Update rate — Day	25 hz.	—	50/60 hz.	50/60 hz.
— Dusk/Night	25 hz.	30 hz.	30 hz.	30 hz.
Displayed polygons — per channel	500	225	500	1,000
— per viewpoint	2,000	1,800	4,000	8,000
Colored lights displayed — per channel				
Day	1,000	—	1,000	1,000
Dusk/night	1,000	4,800	5,000	5,000
Colored lights displayed — per viewpoint				
Day	4,000	—	8,000	8,000
Dusk/night	4,000	38,400	40,000	40,000
Display format	Raster	Raster/Calligraphic	Raster/Calligraphic	Raster/Calligraphic
Resolution (pixels per channel)				
Standard	307,200	360,000	360,000	360,000
High resolution	—	—	720,000	720,000
Scan standard	640 x 480	Programmable	Programmable	Programmable
Active color palette	256	256	256	256
Moving models	3 to 13	3 to 13	3 to 13	3 to 13
Texture				
Modulation	Y	Y	Y	Y
Contour	—	—	opt.	Y
On-line texture maps	32	32	32 (256 opt.)	256
Non-linear image mapping	—	—	—	Y
Line-of-sight ranging	—	—	—	Y

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Exact specification may depend on system configuration and trade offs to meet user performance requirements. 11/89